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(54) **GAS TURBINE BLADE TIP CLEARANCE CONTROL STRUCTURE**

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(51) **Int. Cl.**[7] **F01D 11/08**

(52) **U.S. Cl.** **415/173.1**; 415/173.3; 415/176

(58) **Field of Search** 415/173.1, 173.2, 415/173.4, 175, 176, 178, 116, 173.3

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(57) **ABSTRACT**

A turbine blade tip clearance control system has a rigid two part outer casing **(42)** which sandwiches a control ring **(48)** therebetween, and an air pressurised flexible inner casing **(28)** which carries shroud segments **(22)** within it. Struts **(40)** span the annular space between the casings **(42, 28)** and prevent flexing of casing **(28)** until blade tip clearance needs adjusting, whereupon, ring **(48)** is heated, along with the adjacent portion of outer casing **(42)** and expands, allowing casing **(28)** to flex outwards, thus lifting the shroud segments **(22)** away from the blade tips **(24)**.

Closure of the tip clearance is achieved by cooling ring **(48)**, the resulting contraction thereof, via the struts **(40)**, flexing the inner casing **(28)** and shroud segments **(22)** inwards, against the air pressure.

6 Claims, 2 Drawing Sheets

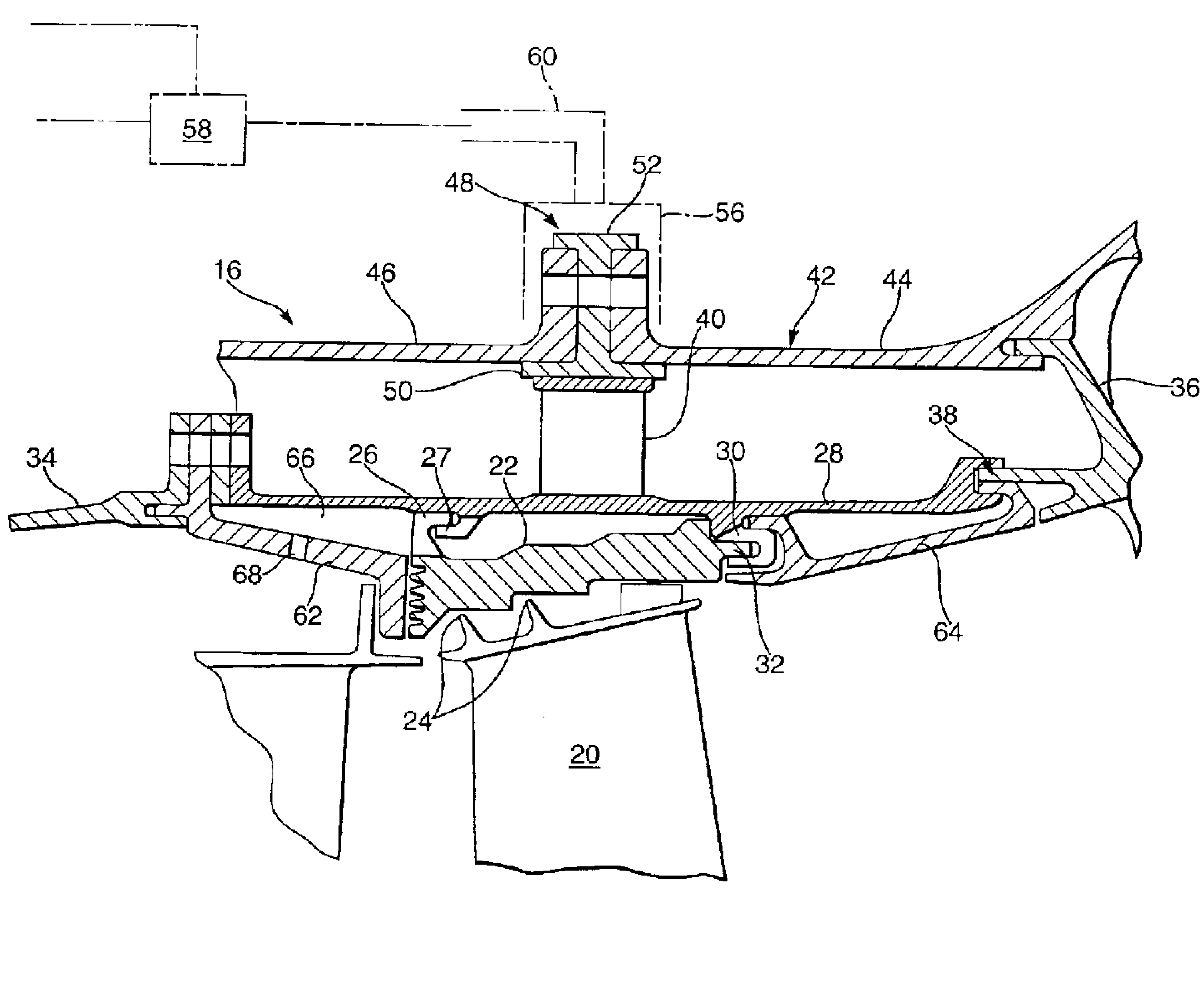


Fig.1.

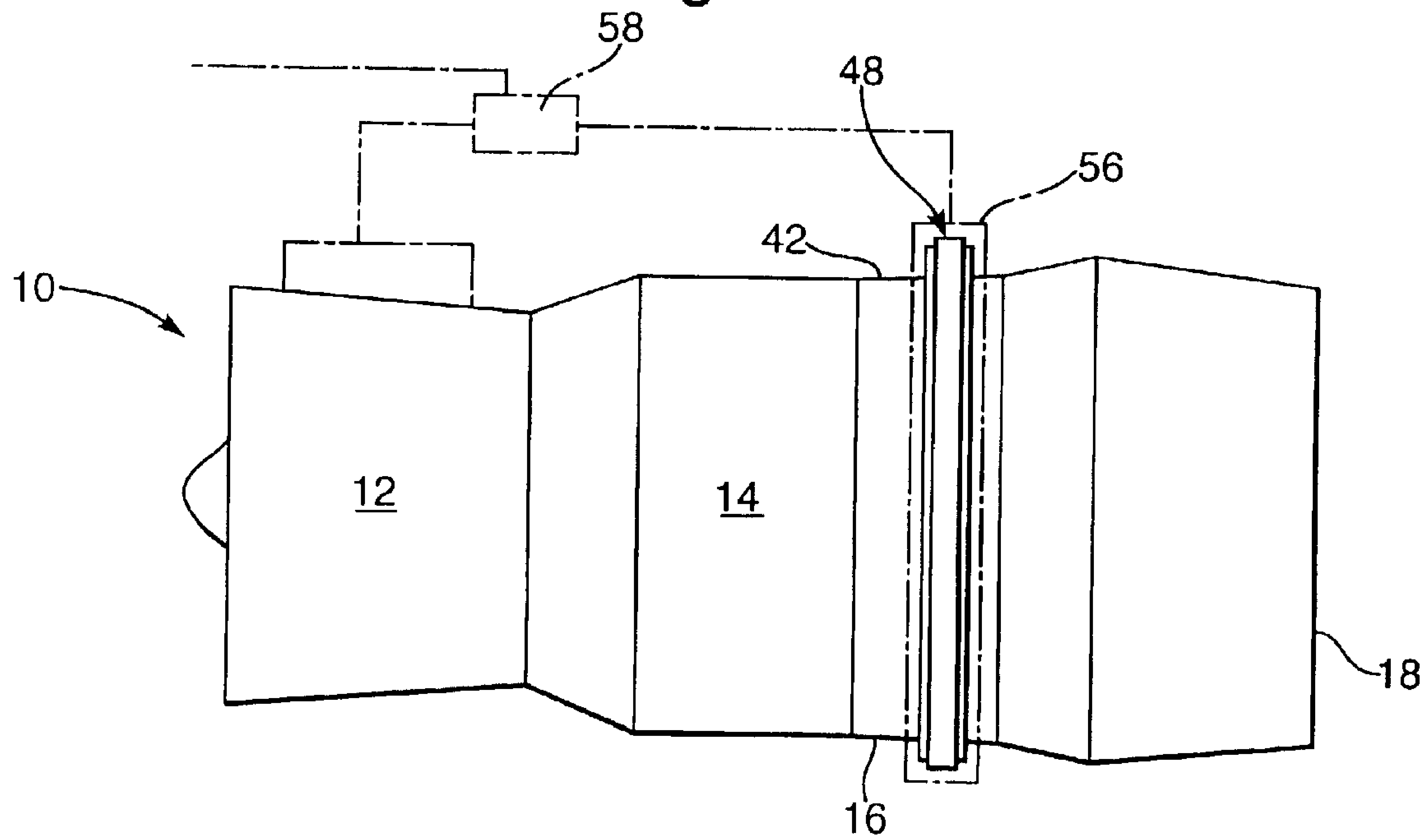
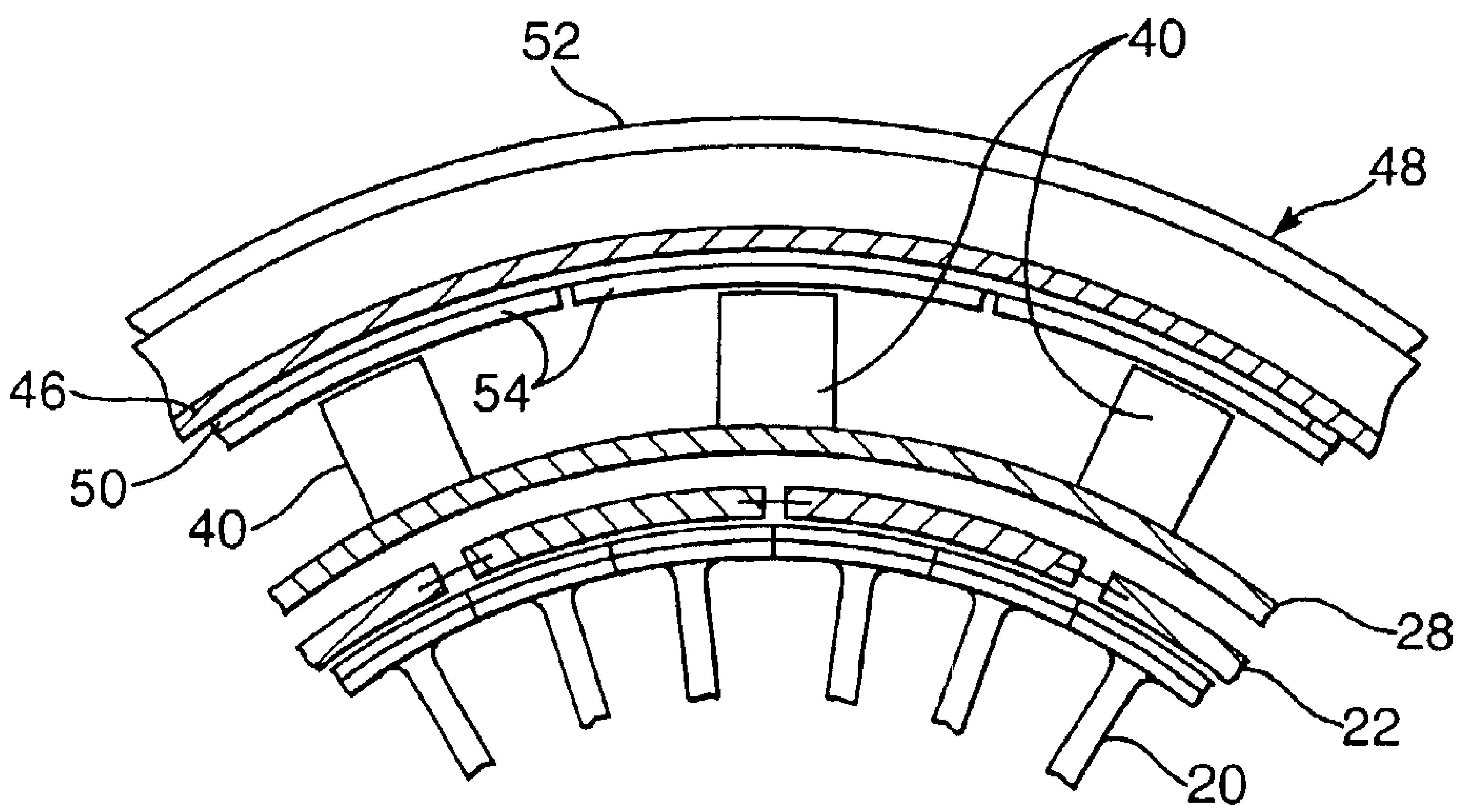


Fig.3.



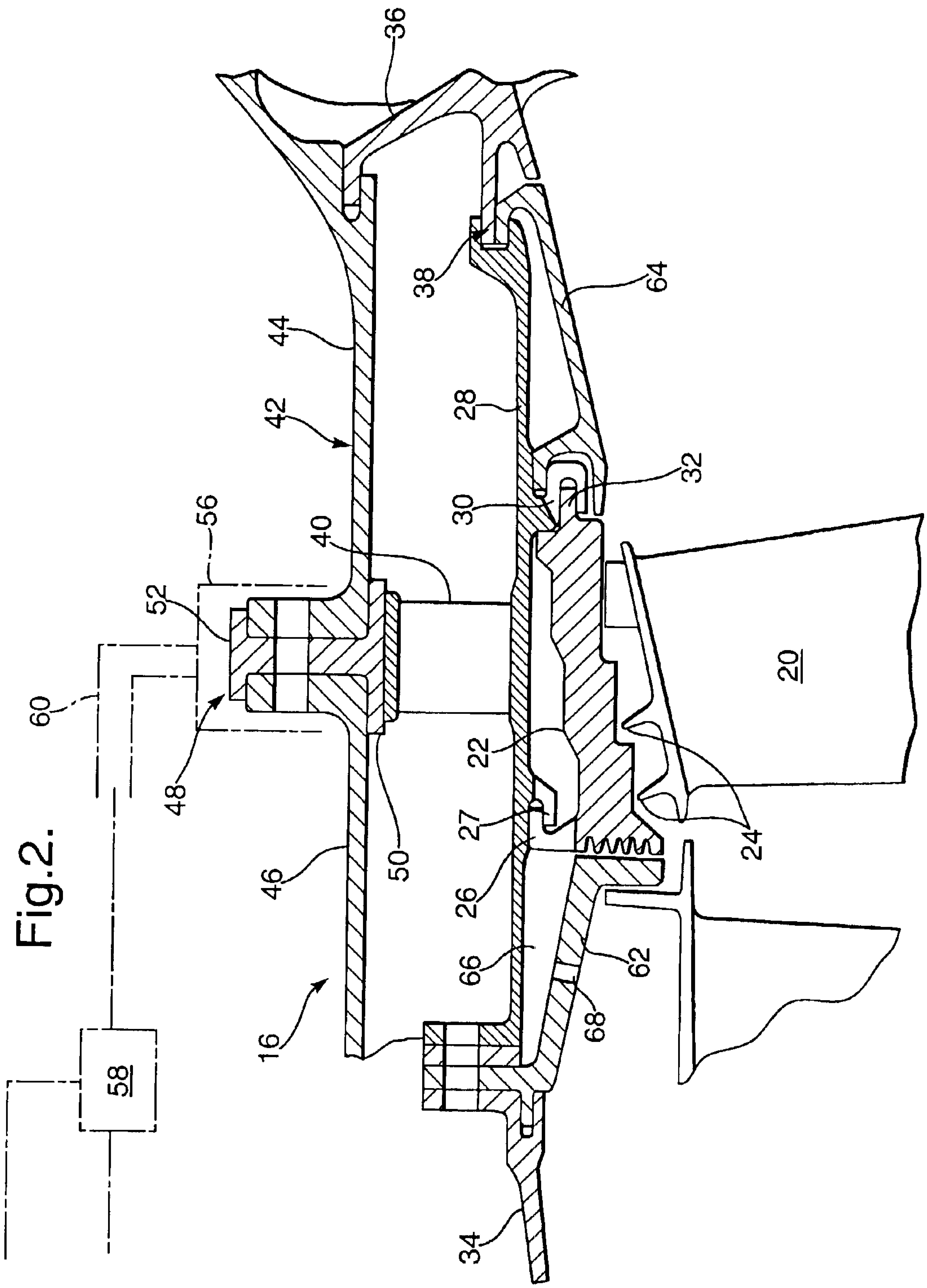

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Fig.2.

GAS TURBINE BLADE TIP CLEARANCE CONTROL STRUCTURE

FIELD OF THE INVENTION

The present invention relates to a structure within which a stage of turbine blades rotates, during operation of an associated gas turbine engine.

More specifically, the structure is of the kind which may be caused to expand and contract along lines radial to the axis of rotation of the stage of turbine blades, so as to at least reduce the magnitude of blade tip rub on structure immediately surrounding them.

BACKGROUND OF THE INVENTION

Devices are known, which are designed to expand radially about a stage of turbine blades, so as to maintain a desirable clearance therebetween. A first example is described and illustrated in published patent specification 1484936. In that example, non rotating shrouds surround a stage of turbine blades. The downstream ends of the shrouds are hooked on a first expandable ring, which is located by radial dowels. The shrouds ends are also hooked in a ring of different expansion and contraction characteristics from those of the first ring. The upstream end of each shroud has an arm fixed thereto by one end, the other end having a ball thereon, which pivots in a socket in fixed structure when the first ring expands as a result of being heated, thus enabling, the first ring to lift the shrouds away from the tips of the blades. The other ring prevents too rapid movement of the shrouds towards the tips of the blades when cooling occurs.

A further example is illustrated and described in published patent specification 1605403. A turbine casing surrounds a stage of turbine blades, which again, include spaced, non rotatable shrouds. A polygonal member surrounds the turbine casing, and has radially arranged bolts fixed thereto so as to project radially inwards, towards the shrouds. The bolts heads locate in the opposing ends of expandable segments which surround the shrouds, which segments in turn, are hooked via their centre portions, to the opposing ends of the respective shroud segments. When the expandable segments are heated, they expand about their centres, into arched forms, thus lifting the shroud segments away from the tips of the blades.

Both examples of prior art disclosed hereinbefore rely entirely on expansion, and are comprised of a multiplicity of parts, which are extremely expensive to produce, and results in complexity of assembly. In the former example, there are provided valve mechanisms which themselves must be expanded, so as to enable heat to reach the shroud moving mechanism. In the latter example, accurate movement of the blade shroud segments about the pivot point of their respective arms, raises the need for, possibly, undesirably large clearances between their downstream extremities and structure adjacent thereto, and thus would reduce turbine efficiency through gas leakage.

SUMMARY OF THE INVENTION

The present invention seeks to provide an improved gas turbine blade tip clearance control structure.

According to the present invention, a gas turbine engine turbine blade tip clearance control system comprises a rigid outer casing connectable to a variable temperature air supply, a flexible inner casing having an inner surface connectable to a pressurised air supply, and supporting a

circumferential array of shroud segments therewithin, an equi-angular array of struts separating said casings, whereby, in operation in a gas turbine engine, said outer casing is expandable and contractable by application of hot or cold air thereto, to allow or prevent, via said struts, pressurised air acting on said inner casing inner surface, to flex said inner casing.

DESCRIPTION OF THE DRAWINGS

The invention will now be described, by way of example, and with reference to the accompanying drawings, in which:

FIG. **1** is a diagrammatic representation of a gas turbine engine incorporating blade tip clearance control structure in accordance with the present invention.

FIG. **2** is an enlarged, cross sectional view of the encircled portion in FIG. **1**.

FIG. **3** is a view on line **3**—**3** of FIG. **2**.

DESCRIPTION OF THE INVENTION

Referring to FIG. **1**. A gas turbine engine **10** has a compressor **12**, a combustion section **14**, a turbine stage **16**, and an exhaust nozzle **18**, all arranged in flow series in known manner.

Referring now to FIG. **2**. The turbine stage **16** includes a rotary stage of turbine blades **20**, only one of which is shown. The stage of blades **20** is surrounded by a ring of shroud segments **22**, which, in, a non operative mode of engine **10**, are very closely spaced from the tips **24** of respective blades **20**. The spacing is achieved by supporting the shroud segments by cooperating hooked features **26** and **27** on their leading edges, and on the interior of a flexible casing **28** and by 'birdmouth' joints **30** on the interior of flexible casing **28**, cooperating with spigots **32** on the trailing edges of the shroud segments **22**. Although in this particular case a 'birdmouth' joint **30** is employed other fastening devices such as hooks could be employed likewise the spigots **32** could be replaced by an alternative fastening device such as a hook or lip.

Casing **28** is fixed in its upstream end it to further casing structure, **34**, which extends towards or over the combustion zone **14**. The downstream and of casing **28** is supported on further fixed structure **36**, via a sliding 'bird mouth' joint **38**, which enables some axial movement thereof, through casing **28** flexing during operation of engine **10**. Again, although a 'bird mouth' joint **38** is employed, other suitable joint arrangements which provide the necessary degree of sealing, may be used.

Casing **28** has a number of struts of substantial proportions projecting radially therefrom, in equi-angularly spaced array, the outer ends of which indirectly abut the inner surface of a rigid, low flexibility outer casing **42**, thereby supporting casing **28** against flexing under air pressure loads and mechanical generated during operation of engine **10**.

During at least some operating conditions of engine **10**, blades **20** will expanded radially outwards, and shroud segments **22**, must also be moved outwards, so as to eliminate or at least minimize rubbing of the blades tips **24** against them. To this end it, casing **28**, is made from a material, which is of such proportions, and is a sufficiently flexible, as to enable it to achieve the desired adequate movement. However, because struts **40** are present, that circumferential portion of rigid casing **42**, which surrounds struts **40** must also be movable. In a radially outward direction, which is explained later in this specification. The relevant portion of casing **42** is made up from two axially short casings. **44** and **46**, which are fixedly joined via flanges, which sandwich a ring **48** therebetween. Ring **48** has an inner land **50** and an outer land **52**, which overlap in their respective interfaces with the casings **44** and **46**.

A thin segmented ring **54** is positioned between the inner land **50** and the struts **40**, and acts as a thrust load distributor, when radial loads are experienced by struts **40** and ring **48**, as is explained hereinafter.

Prior to start up of engine **10**, casing **28** holds shroud segments **22** in close spaced relationship with the blades tips **24**. When engine **10** is started, and runs at idle speed, there is insufficient growth of turbine blades **20**, to require flexing of casing **28**, to cause movement of shroud segments **22** away from blades **20**. However, when an aircraft (not shown), driven by engine **10**, takes off, engine **10** is accelerated it to full thrust, at which time, its operating temperature rapidly increases, and, consequentially, so does growth of blades **20**. It then becomes necessary to flex casing **28**, to move shroud segments **22**, so as to at least reduce rubbing of blade tips **24** against them.

As stated hereinbefore, in order that casing **28** may flex radially outwards of the axis of engine **10**, the portion of rigid outer casing **42** which is in radial alignment with struts **40** must be caused to move in the same direction. This is achieved by heating the flanged joint and ring **48** which is sandwiched therebetween. A cowl structure **56** is provided, which surrounds the flanged joint and ring **48**, and hot air derived from an appropriate region of the compressor **12** is directed thereto via a control valve **58**, and a conduit **60**. The flanged joint and ring **48** then expand, and thus enable struts **40**, and casing **28** to follow, without losing contact therewith.

Flexing of casing **28** is achieved as follows. Shroud **30** segments **22**, with respective casings **28**, **62** and **64**, form an annular space **66**, which, via a circumferential array of apertures **68**, only one of which is shown, is in permanent flow communication with a high pressure stage in the compressor **12**. As the pressure of the air delivered from compressor **12** increases during the aforementioned aircraft take off stage, it reaches a level within space **66**, at which together with thermal distortion of the casing **28** it forces casing **28** to start flexing in a radially outward v direction. Shroud segments **22** are thus lifted away from blade tips **24**.

When engine **10** is throttled back, as occurs when the aircraft is required to fly at cruise speeds, compressor delivery pressure will reduce, and casing **28** will begin to flex radially inwards, to the points where it attains not quite its original cold shape. This provides an appropriate spacing between shroud segments **22** and blade tips **24**.

In order that ring **48**, via segmented ring **54**, maintains or subsequently resumes its indirect contact with struts **40** when casing **28** flexes or has flexed radially inwards, ring **48** and associated flanges must be cooled, so as to cause them to contract at a rate which will ensure constant contact therebetween. This is achieved by directing air from the upstream, low pressure, low temperature portion of compressor **12**, via valve **58**, into cowl **56**, thus enveloping ring **48** and associated flanges therewith.

The appropriate actuation of valve **58**, in order to match flexing of casing **28**, and expansion of ring **48** and associated flanges, with blade tip clearance during varying engine running conditions, may be achieved in a number of ways, including developing electronic signals from any engine measurable operating parameters, such as engine revolutions, engine pressures, and engine air and/or gas pressures, and utilising those electronic signals to actuate valve **58**, so as to direct air of appropriate temperature, or pressure, to appropriate parts.

Casing **28** is flexed by the application of pressure to its inner surface in combination with mechanical and thermal loads, and is subjected to that pressure through all of the working regimes of engine **10**. Therefore, a counter pressure is applied to the outer surface thereof, which, combined with the inherent self supporting stiffness possessed by casing **28**, is sufficient to prevent undesirable flexing, anywhere along its length. FIG. **3** illustrates the positional relationship between the struts **40** and the segmented load distribution ring **54**, which is seen to be split at mid point **70** between each pair of adjacent struts **40**. FIG. **3** also depicts the angular positioning of struts **40** with respect to flexible casing **28**.

What is claimed is:

1. A gas turbine engine turbine blade tip clearance control system comprising a rigid outer casing connectable to a variable temperature air supply, a flexible inner casing having an inner surface connectable to a pressurised air supply and supporting a circumferential array of shroud segments therewithin, an equi-angular array of struts separating said casings, whereby, in operation in a gas turbine engine, said outer casing is expandable and contractable by application of one of hot and cold air thereto, to allow or prevent, via said struts, pressurised air acting on said inner casing inner surface, to flex said inner casing as the result of the pressurized air acting separately from any other effects on said inner surface when said gas turbine engine is in operation.

2. A gas turbine engine blade tip clearance control system as claimed in claim **1** wherein said struts are affixed to the outer surface of said inner casing.

3. A gas turbine engine turbine blade tip clearance system comprising a rigid outer casing connectable to a variable temperature air supply, a flexible inner casing having an inner surface connectable to a pressurised air supply and supporting a circumferential array of shroud segments therewithin, an equi-angular array of struts separating said casings, whereby, in operation in a gas turbine engine, said outer casing is expandable and contractable by application of one of hot and cold air thereto, to allow or prevent, via said struts, pressurised air acting on said inner casing inner surface, to flex said inner casing wherein said outer casing comprises a pair of casing members having opposing flanged ends, between which a ring is sandwiched in radial alignment with said struts.

4. A gas turbine engine turbine blade tip clearance control system as claimed in claim **3** wherein said ring has inner and outer lands, which overlap respective interface joints between the said ring and said flanges.

5. A gas turbine engine turbine blade tip clearance control system as claimed in claim **4** including a multi-segmented ring, which is located in between the ends of said struts and the radially inner surface of said inner land, whereby to act as a distributor of loads generated by interaction between said struts and said landed ring during expansion or contraction thereof.

6. A gas turbine engine turbine blade tip clearance control system as claimed in claim **1** wherein said flexible inner casing is combined with further casings respectively upstream and downstream thereof, and with said shroud segments, to define a pressure chamber connectable to said pressurised air supply, so that, on receipt of pressurised air therein, a flexing force is applied to the inner surface of said flexible inner casing.

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